

Lawrence Livermore National Laboratory

Science and Technology

The Computation, Engineering and Physical and Life Sciences directorates provide the leading-edge science and engineering capabilities that enable Lawrence Livermore National Laboratory (LLNL) to anticipate, innovate and deliver solutions to problems of national importance.

This nation's security and prosperity are directly linked to U.S. preeminence in science and technology. Science and technology brought an end to World War II, put men on the moon and revealed the building blocks of life. Science and technology gave rise to microchips, the Internet, and a multitude of consumer products that drive the U.S. economy. Over the last half-century, 50 to 85 percent of the growth in the U.S. gross domestic product is attributable to advancements in science and engineering.

Today, science and technology hold the key to solving many of the most serious challenges facing the country. To prevent nuclear terrorism, new technologies are needed that can rapidly detect small or shielded quantities of nuclear materials. Widespread outbreaks of bacteria in food products and pandemics highlight the speed with which pathogens can spread and the need for improved disease detection capabilities. Perhaps most important, the world needs new sources of energy coupled with an understanding of the influence of human activities on global climate to ensure that new energy technologies do not harm the environment.

LLNL applies its unique experimental facilities, world-class computing resources, and multidisciplinary expertise to tackle these and other nationally important problems.

Computation

High-performance computing is one of the Laboratory's signature strengths. LLNL's supercomputers are among the fastest in the world. A calculation that took an entire day in 1995 now takes only one second or less. One of these machines — Sequoia — was ranked the fastest computer in the world on the June 2012 Top500 list of the world's most powerful computers. Clocking in at 16.32 sustained petaflop/s (one petaflop equals one quadrillion floating point operations per second), this IBM BlueGene/Q supercomputer is a world leader in both peak speed and power efficiency. A smaller 5 petaflop/s version of Sequoia, called Vulcan, is dedicated to Lab collaboration with industry and academia to spur economic growth.

LLNL computer scientists develop the tools, technologies, and applications, including state-of-the-art capabilities in mathematical modeling and scientific visualization, needed to exploit the full potential of these powerful machines. Researchers at LLNL and the other national laboratories use the computers to study, at a first-principles level, such phenomena as the interactions between individual atoms and electrons (necessary to understand the behavior of materials at their most basic level) or the turbulence that results when a shock wave passes through a fluid (important for understanding the physics of combustion, supersonic vehicle propulsion and the evolution of supernovas).

Using the short-pulse, ultra-intense Titan laser, LLNL scientists are able to produce more positrons faster and in greater density than ever before, making possible new research into the nature of antimatter.

* Casey Coleman, Innovation in the Business of Government: A GSA Blog, 28 April 2009: <http://blogs.gsa.gov/blogs/OCIO.nsf/archive?openview&title=Competitiveness&type=cat&cat=Competitivenessarchive?openview&title=Competitiveness&type=cat&cat=Competitiveness>

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The 20-petaflop Sequoia supercomputer boasts more than 1.5 million processing units, or cores, arranged in a compact, water-cooled, energy-efficient system. Its processing power is compressed into 96 racks, each the size of a large refrigerator, arrayed across 3,400 square feet of floor space.



Engineering

Engineering at the Laboratory encompasses all facets of the discipline. LLNL engineers design, construct and operate a host of large, complex mechanical, electrical and optical systems, including the 192-beam National Ignition Facility, the High Explosives Applications Facility, with its fully contained detonation tanks, and the tandem Van de Graff accelerators at the Center for Accelerator Mass Spectrometry. LLNL engineers are central to all aspects of the Stockpile Stewardship Program. They also design and fabricate nanoscale devices, such as laser fusion targets, miniaturized chemical and biological detectors and even a retinal prosthesis that can restore sight to the blind.

LLNL is helping to push the state of the art in such new engineering technology fields as additive manufacturing, notably conceptualizing parts using computer-aided design tools.

Many of the technologies, devices and processes developed by LLNL have commercial applications, and the Laboratory works with industry partners to move these advances into the marketplace. Notable technology transfer successes include the miniature thermal cyclor that permits rapid DNA analysis within minutes instead of days and a compact proton accelerator for cancer treatment that precisely targets tumors and leaves the surrounding healthy tissue untouched.

Physical and Life Science

LLNL scientists are active in all aspects of modern physics, from the first-ever simulation of early stage radiation damage to a new forensic approach for identifying human remains.

Laboratory researchers simulated and quantified the early stages of radiation damage that will occur in a given material.

For more information, contact the LLNL Public Affairs Office, P.O. Box 808, Mail Stop L-3, Livermore, California 94551 (925-422-4599) or visit our website at www.llnl.gov.

LLNL is managed by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy, National Nuclear Security Administration, under Contract DE-AC52-07NA27344.

LLNL-BR-423446



The new method opens up the possibility of predicting the effect of radiation on a wide range of complex materials, from the nuclear field to the space industry to medicine.

In chemistry, scientists at LLNL have been involved in heavy element research since the Laboratory's inception in 1952, and have been collaborators in the discovery of six elements - 113, 114, 115, 116, 117 and 118. Most recently, element 116 was named Livermorium after the Laboratory and the city of Livermore.

The material science realm brought about the discovery that plastic scintillators developed for detection of nuclear material provides protection of ports and large facilities. The new technology could assist in detecting nuclear substances such as plutonium and uranium that terrorists might use in improvised nuclear devices, and could help in detecting neutrons in major scientific projects.

Livermore scientists made contributions to keeping U.S. troops safe through the development of carbon nanotube technology -- special molecules made of carbon atoms in a unique tubular arrangement -- that was initially developed for desalination and is now being transformed into fabric that could protect troops in the field by repelling chemical and biological agents.

LLNL is a world leader in atmospheric science and climate modeling. Through detailed modeling, scientists have provided a better understanding of the causes and effects of climate change. By analyzing observations and results obtained from climate models, an LLNL study showed that previously rare high summertime temperatures are already occurring more frequently in some regions of the 48 contiguous United States.

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